MARINE BOTANY OF THE KENYA COAST 3. GENERAL ACCOUNT OF THE ENVIRONMENT, FLORA AND VEGETATION

By

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ACKNOWLEDGEMENTS

The work on which this general account is based was made possible by the generous grants awarded by the Rockefeller Foundation to whom we tender our thanks.

We wish to thank Mrs. Pauline Hall for those drawings of marine algae initialled P.H. and for the drawing of *Turbinaria ornata* we thank Miss Fay Anderson. For information regarding *Turbinaria kenyaensis* and *T. crateriformis* in the Dar es Salaam region we are indebted to Dr. Erik Jaasund, Botany Department, University College, Dar es Salaam.

INTRODUCTION

From north to south, Kenya extends over about 10° latitude while the coastline has a latitudinal extent of about a third of this—from about latitude 1° 40″S. to about 4° 41″S. Further, as compared with the coasts of Norway or the west of Scotland the coastline of Kenya is relatively little indented. Where the coastline is broken or where there are deep inlets, these are in the nature of creeks flanked by mangrove which are characteristic especially of the extreme north and south of this region. The total coastal area of Kenya is relatively small. While the land surface of Kenya extends well north of the equator, the coastline lies entirely to the south of it. (Fig. 1).

The algal flora of the Kenya coast is a rich one and much work will be involved in collecting and identifying all the species that occur on these coasts. A number of new species can also be expected—two new Turbinarias have already been described (Taylor, 1966). The species named in this paper and included in the two lists so far published (Isaac, 1967, 1968) by no means exhaust the roll call of species. The number of small epiphytic species is likely to be appreciable.

* Note the authorities for the Latin names of the Algae can be found in the two Lists, Marine Botany of the Kenya Coast I and First List of Kenya Marine Algae, J. E. *Afr. Nat. Hist.Soc.* **26:7** 5 and on p. 1 of this number.

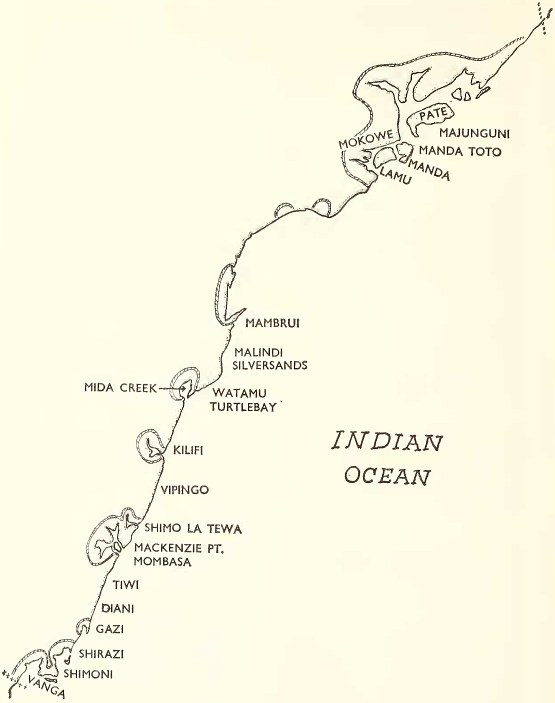

Fig. 1

Kenya Coastline indicating localities referred to and where collections have been made. The areas between the hatched double lines and the shores and the adjacent islands have extensive mangrove forests.

The Tropical waters of the Western Indian Ocean

The simplified general account given below and in the following two sections is based on the relevant parts of the "Africa Pilot" (1954), Newell's monograph (1957) and a popular account in relation to Fisheries by Morgans (1959b).

The stratification of the Western Indian Ocean waters is diagramatically summarised by Newell in Fig. 4 of his monograph. This figure indicates the following layers off the Kenya coast:

(a) Tropical surface water: high temperature, high salinity, oxygen saturated.

(b) Arabian Sea water: high salinity, low oxygen.

(c) Antarctic Intermediate water: low salinity, high oxygen.

(d) North Indian Deep water: a Red Sea outflow of high salinity and low oxygen.

In his simplified account Morgans refers to a surface water layer overlying Arabian Sea water.

Newell's account is based on results obtained in Cruises No. 43 to No. 66 of M.F.R.V. *Research* and cruise No. 67 carried out by M.Y. *Tchita* in 1952, 1953 and 1954 as well as on relevant results obtained during previous Expeditions and especially the *Valdivia, Daona* and *John Murray* Expeditions of 1898–9, 1928–30 and 1933–4 respectively. The area with which Newell was concerned extended from the southern border of Tanzania to the northern border of Kenya and for a distance of. thirty miles out to sea from the shore and including the islands of Mafia, Latham, Zanzibar and Pemba.

The continental shelf is for the most part very narrow off the East African coast, usually extending only two to five miles offshore. The stratification indicated above extends up to the fringing reefs. There is no evidence of a mixing of water masses due to upwelling or downwelling although the lower limit of the upper layer is marked by a relatively rapid temperature change within a relatively short vertical distance, i.e., a thermocline. The depth at which this thermocline occurs, however, undergoes changes.

The water moving over the reefs is that of the surface or upper layer of the adjacent sea unaffected, as mentioned above by upwelling. The thermocline apparently never reaches the reefs. Thus the sea temperatures of the upper layer allow of the development of coral reefs along the whole of the Kenya coast.

The East African Coastal Current

The westward moving South Equatorial Current of the Southern Hemisphere reaches the African coast at about Cape Delgado, about 11°S. latitude. Here arise the southward flowing Mozambique Current and the northward flowing East African Coastal Current. We are concerned only with the latter which governs conditions in the upper stratum of the sea. (Fig. 2 and 3).

The northward extent of the East African Coastal Current varies with the two major monsoon seasons to which the coast is subject but it flows constantly northwards from the southern boundary of Tanzania to at least Malindi. During the south-east monsoon period it continues northwards to Cape Guardafui (Horn of Africa). In broad terms, and disregarding annual variations and transition phases, this extends from April to October/November. During the period of the north-east monsoons from about November to March, however, the northward extent of the East African Coastal Current is more restricted. In this season it meets the southward flowing waters of the Somaliland coast. These two streams of water turn eastwards and join to form the Equatorial Counter Current. In weak north-east monsoons the two streams meet and turn east, north of Lamu. Newell states that this may take place as far north as the equator or at about 1°S. latitude. In strong north-east monsoons on

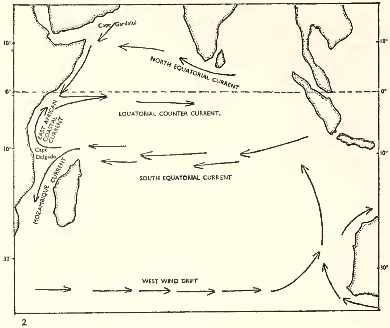

Fig. 2

Indian Ocean in the Southern Summer showing direction of Ocean Currents (after Newell).

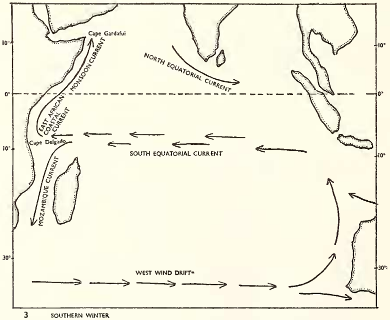

Fig. 3

Indian Ocean in the Southern Winter showing direction of Ocean Currents (after Newell).

the other hand, the meeting of north and south flowing waters is much further south and may occasionally be as far south as Malindi. (Fig. 2 and 3).

The vertical thickness of the East African Coastal Current is greatest towards the end of the south-east monsoon when it reaches a depth of 60–70 fathoms. During the north-east monsoon the vertical thickness is minimal extending at a depth of 30 to 50 fathoms.

The monsoons affect not only the northward extent and speed of the East African Coastal Current but also the salinity of the waters. During the south-east monsoon the shifting of ocean currents brings Pacific water of high salinity into the South Equatorial Current while during the north-east monsoon the South Equatorial Current draws water of low salinity from the Malay Archipelago region. These changes in turn result in corresponding higher and lower salinities of the East African Coastal Current waters. A further factor in relation to salinity is the incidence of rainfall, especially the heavy rains of March to May. From April to June the outflow from the five principal rivers is at its maximum. Prevailing conditions, however, result in the brackish outflow of rivers being kept mostly inshore but according to Morgans rain and river spate reduce salinity only a fraction.

On the basis of Newell's figures surface waters vary from about a minumum of 34.5 to a maximum of 35.4 salinity. As far as the plants of the intertidal region and shallow water are concerned, this variation range is not likely to be significant. Local inshore salinity variations due to brackish water springs flowing on to the shore, or to the immediate proximity of a large river may, however, have significant effects. Such situations favour luxuriant growths of *Enteromorpha* and, near fresh water outflows, local growths of *Grateloupia filicina* and sometimes of the ubiquitous *Centroceras clavulatum* may be found.

The surface sea layer throughout the year has a high oxygen content, almost at saturation. The oxygen content, on the other hand, usually begins to decrease before the thermocline is reached.

Sea Temperatures

Only limited temperature data are available for the region: most of the data were recorded in 1953 and 1954. The available records are of surface temperatures of coastal waters. No records are to hand of inshore temperatures. Coastal surface waters give the general order of temperature but the actual temperatures of inshore waters will vary appreciably depending on local variations in depth, inflow of fresh water and the degree of imprisonment of small bodies of water cut off to a greater or lesser extent from the inflow of water from adjacent areas. On a micro-habitat scale, a walk across a reef at low water will demonstrate appreciable temperature differences between skins of quiet water over a substratum; water of small and large, deep and shallow pools; deep gulfs of water cutting across the reef; and the seaward edge of a reef where water is constantly washing in and out from the open sea.

The average monthly temperatures of surface waters for the whole East African Coast range from 24.8°C. to 29.1°C., the lowest and highest single temperature records being 24.3°C. and 29.7°C. respectively. A South-North sequence of temperatures would have been of interest. An indication is given by four bathy-thermograph tracings, two for Lamu in the North and one each for Kilwa and Mtwara in the South. These indicate somewhat lower temperatures at Lamu than at the two southern stations.

The highest average monthly temperature was recorded for March and lowest for September and in between there was a gradient of decreasing temperatures. After September, average monthly temperatures rose again. This gradient is correlated with the monsoons. As the south-east monsoon develops, the surface water becomes cooler. The north-east monsoon period is generally one of gentle winds and as a consequence the East African Coastal current from December to April becomes layered, a surface skin 10–40 ft. deep of sun-warmed waters floating on colder water below. It is this uppermost layer which attained the March monthly average of 29.1°C. recorded in 1953.

Effects of water movements along East African Coasts on the distribution of plants and animals

To what extent these water movements affect the plants and animals of the intertidal region and shallow waters future investigations will show. There are, however, indications that the distribution of algae and marine angiosperms along the Kenya coast is affected to some extent.

Morgans (1959 a. & b.) suggests that the current flowing southwards along the Somaliland coast might account for a species of rock cod (Serranidae) being caught in fair numbers off Lamu but not further south. According to Morgans this is probably the same fish which is trawled in great numbers just south of India; in which case, it would extend across the northern Indian Ocean and down the African coast to Lamu.

It may also be of significance that a plant of *Scinaia indica* Boergs. was collected cast up at Turtle Bay, Watamu District—the first and only plant so far collected on the Kenya coast. It was recorded by Boergesen from the north-west coast of India; dredged up from about 10 metres at Dwarka and cast up at the nearby Okha Port (Boergesen, 1931).

Two new species of *Turbinaria* have been described by Taylor, viz., *T. kenyaensis* and *T. crateriformis* (Taylor, 1966). They are common on the reef of the South Kenya coast. Fertile specimens of these species have been collected in the Turtle Bay area of the Watamu region. A few stunted, non-fertile plants of *T. kenyaensis* were also found in early December 1967 on the Silversands reef (Malindi). Here this contrasted with the abundance of large fertile *T. murrayana* near the reef edge and of fertile *T. conoides* in quiet water further back from the sea. Fertile plants of *T. kenyaensis* have often been collected in December on the reef at Diani. Neither of Taylor's new species have been found in the Lamu region although more diligent search might reveal them as rare species or of very local occurrence. It is clear, however, that *T. kenyaensis* and *T. crateriformis* are essentially species of the South Kenya coast. This view is confirmed by information received in correspondence with Dr. Jaasund. According to him *T. kenyaensis* is plentiful in the Dar es Salaam area although in that region it shows a marked seasonal fluctuation. On the South Kenya coast moderately large to large fertile specimens have been collected in March, April, June, August and December. Dr. Jaasund has not found *T. crateriformis* in the Dar es Salaam area.

Chamaedoris auriculata was collected by us at a number of places in the Lamu region and Gerloff (1960) records *C. delphinii* from localities in the northern Lamu Archipelago. We found *C. auriculata* in great abundance at Mambrui but nowhere else south of the Lamu region although more intensive collecting may reveal its presence elsewhere. The Mambrui plants were of smaller size than those collected further north. *C. auriculata* occurs on the shores of Dwarka on the north-west coast of India (Boergesen, 1933). *C. delphinii* grows on the east coast of South Africa and northwards to Inhaca Island and Xai-Xai in Mozambique (Isaac, 1956, 1957b); it has also been recorded from Mauritius and Madagascar (Boergesen, 1940). Possibly somewhat higher sea temperatures on the south Kenya coast are less favourable to this species.

Among the species of *Ulva* growing on the Kenya coast are two reticulate forms, including *U. reticulata*. These have been collected by us in abundance on the Kenya coast as far north as Malindi. In places on the outer reef they are very abundant. We have not found reticulate *Ulva* on the northern Kenya coast. It is clear that the reticulate Ulvas are essentially species of the south Kenya coast extending to the coast of Tanzania since a coarse form of *U. reticulata* was observed to be very plentiful around Mafia Island.

Lastly, the case of *Zostera capensis* can be cited. This marine Angiosperm is much more abundant on the north Kenya coast than further south although there is no dearth of equally favourable habitats for it further south.

It is expected that further analysis of records for corresponding habitats will result in a number of additions to the list of species showing a more characteristic north or south Kenya distribution.

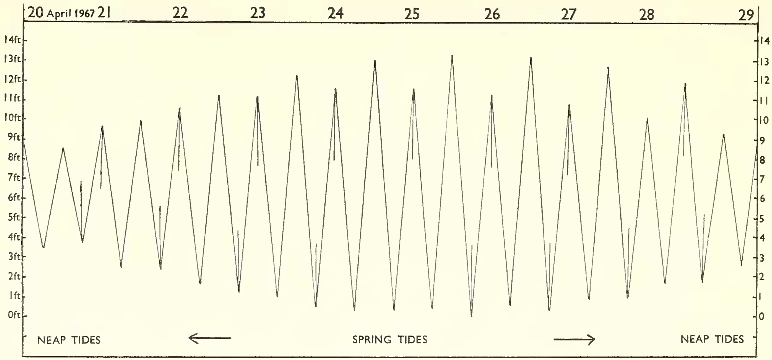

Fig. 4

Graph illustrating the heights of tides at Kilindini Harbour, Mombasa, for the period 20–29th April 1967. (S.E. Monsoon period).

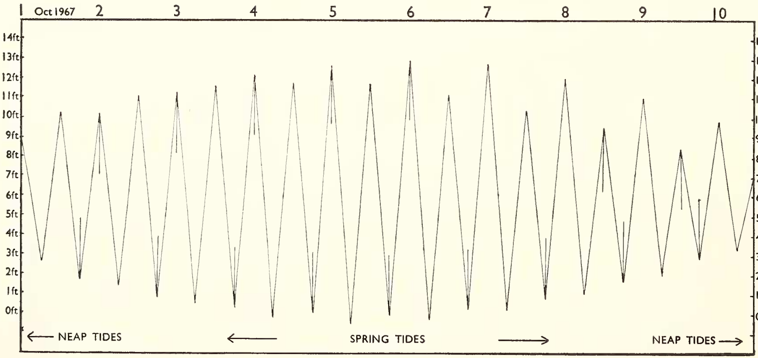

Fig. 5

Graph illustrating the heights of the tides at Kilindini Harbour, Mombasa for the period 1–10 Oct. 1967 (N.E. Monsoon period).

In both graphs above hours of daylight are regarded as 06 hours—18.45 hours. A black line through the peak indicates a high or low tide during hours of darkness. 0 ft. × datum.

Tides

On the Kenya coast there are two tide cycles for every period of somewhat over 24 hours. Except for limited periods in the year, however, the levels of high and low water of each successive tide differ appreciably from the corresponding tide before and the tide following. The tides can thus be designated as mixed tides (Bauer, 1933). This will present a contrast to those familiar only with the semi-diurnal tides around British coasts but will be familiar to those acquainted with Australian or West North American shores. The marked differences which may occur in successive tides is illustrated in Figs. 4 and 5.

Whether the lowest spring tides occur during warmer daylight hours or during the cooler hours of darkness is a matter of extreme importance to biologists studying the biota of the intertidal area and of the shallow seas beyond. Regard being taken only of tides which are no higher at low water than 1.5 ft. above datum, the times of low water of spring tides usually occur between 09.30 hrs. and 13 hrs. during daylight and between 21 hrs. and 01.30 hrs. during hours of darkness. For the years 1965, 1966 and 1967 taking the lowest level for daylight and darkness of each tide cycle irrespective of height in relation to datum, the earliest time of low tide during daylight was 10.07 hrs. and the latest 12.23 hrs., the usual time range for lowest tides being 10.30 to 12.30 hrs. The corresponding times for hours of darkness were 21.51 hrs., and 23.58 hrs. and the range during which most low waters occurred was from 20.15 hrs. to 0.15 hrs.

An analysis of the tide tables published by the East African Railways and Harbours indicates that whether the best working tides are during daylight hours or at night, runs more or less parallel with the monsoons. Apart from some differences from year to year the general picture is as follows. From October to mid-March the lowest tides are during daylight hours. As compared with the corresponding night tides, the daylight low waters are lower by 0.3–1 ft. and mostly lower by more than 0.5 ft. From May to August inclusive, the lowest tides are during hours of darkness and these tides are lower than the corresponding daylight low waters by 0.3–0.9 ft. and are usually 0.5 ft. or more lower. During the second half of March, the first half of April and the whole of September the differences in level between the corresponding daytime and night low waters are small or virtually non-existent. For 1965, 1966 and 1967 the differences at these times do not exceed 0.3 ft. and for more than half of the corresponding pairs of tides the difference is 0.1 ft. or less.

The standard port for Kenya is Kilindini and the level of the sea is expressed as feet above or below datum. The maximum tidal range does not usually exceed about 12.5 feet but may sometimes be over 13 ft.

At any point on the coast there will of, course, be deviations from the data worked out for Kilindini, deviations both in regard to time (e.g. Malindi+5 minutes; Lamu+40 minutes) and to levels. Nor should it be overlooked that published tidal levels are levels calculated on expectation. Unusual winds can have considerable modifying effects.

Seasonal changes in marine flora and vegetation

Detailed studies are needed on the changes in the intertidal vegetation throughout the year in a diversity of localities before any general picture of seasonal changes can be given. The observations we have made, however, indicate that the density of vegetation and variety of species is least towards the end of the October to mid-March north-east monsoon period. This period of relative poverty is the time of year when the lowest Spring tides are during daylight hours and when air temperatures are high. By contrast, during the time of year when the lowest Spring tides are at night and the day temperatures are lower, the inter-tidal vegetation and variety of species is at its optimum. This emerged clearly when we compared conditions on parts of the Manda Island coast in July 1965 and in March 1967. On the first visit there was a density of algal growth at low levels and a richness of species, especially of *Caulerpa*, whereas on the second visit there was a relative sparseness. Again, on the reef shelf between Turtle Bay and Watamu there was a similar contrast as between August 1965 and April 1967.

This difference was also apparent in the mud-flat vegetation at Lamu. In July 1965, *Halodule uninervis H. wrightii, Halophila ovalis* and *H. minor* were plentiful but in March 1967 they were almost absent. *Zostera*, on the other hand, seemed to be unaffected and was present in extensive beds on both occasions. Again, at the north-east corner of Turtle Bay the beds of marine angiosperms were less luxuriant and *Halodule uninervis* had almost disappeared.

Littoral Habitats

Reef and mangrove are the two chief features of tropical shores and the Kenya coast conforms to this pattern since fringing coral reefs are almost continuous except where replaced by mangroves. These latter are often extensive especially along deep inlets from the sea as in Mida Creek, Watamu and Mombasa and bordering relatively narrow channels between islands and between islands and the mainland in the Lamu region. Mangroves are not found where the sea is rough.

While coral reefs and mangroves form, as it were, the general framework on tropical shores, mud, sand-mud and especially sandy areas are extensive and of considerable importance. To seaward of a mangrove the receding tide often lays bare extensive areas of sand, a sand-mud mixture or, as at Mokowe, soft fine mud. Again on the shore behind the reef there may be extensive sandy areas which stretch to a greater or lesser degree into breaks and depressions of reefs. On sandy areas in shallow intertidal waters and in the sub-littoral the most prominent plants are the marine angiosperms popularly known as "sea grasses". They also occur on rocky areas with an overlay of sand. These marine angiosperms are a characteristic feature of tropical shores.

The white line of the waves breaking on the seaward edge of the reef is a familiar sight off Kenya coasts. The distance of the reef edge from the shore varies from place to place, the distance at some points being considerable but an inspection of survey maps indicates that for the most part, the reef edge lies about .25 to .75 of a mile off shore. During low water of a favourable spring tide it is possible to walk on uncovered or almost uncovered reef platform or through a greater or lesser depth of water to the reef edge. In places deeper water channels cut across the platform and thus, while collecting material, it is advisable to have a boat in attendance. Although the platform surface as a whole shows a gentle slope from shore to reef edge, the surface is very uneven, with parts completely uncovered, parts with shallow water, larger and smaller pools and channels. Because of this general character of the reef platform it will be realised:

1. That although relatively few plants and animals remain uncovered at low water at the upper levels of the shore there is a considerable area available for intertidal organisms due to the gentle slope of the platform in conjunction with the appreciable tidal amplitude.

2. The uneven character of the reef surface together with the existence of many pools ranging in depth from little more than water skins to deep pools makes it difficult to recognise zones or girdles of algae such as have been delimited for West European coasts. The difficulty is enhanced by the richness of the flora and the variation from place to place.

As more investigations are carried out on these coasts it should become increasingly easier to characterise species broadly in relation to tidal levels. The picture is likely to be complicated by a consideration of the importance of other factors such as the greater turbulence of the waters at and near the reef edge. There is practically a continuous cover of live coral exposed at low water level of spring tides on the outer reef at Silversands, Malindi. Here there is a relative paucity of plant growth. This illustrates the general phenomenon that a dominance of either plants or animals on a particular area of the intertidal zone results in the near absence of the other as far as macroscopic organisms are concerned.

Exceptions to the absence of species uncovered by the receding tide at higher shore levels are the communities of small algae on shaded rock faces and overhangs where old coral cliffs occur high on the shore. Some of these plants may remain uncovered for a few days during neap tides. *Bostrychia binderi* in general dominates these communities. On some shores certain species such as *Pelvetia canaliculata* (e.g. Isaac, 1933, coast of Glamorgan) and *Porphyra capensis* (Isaac, 1957a, coast of South Africa), have been shown to survive considerable water losses during emersion. From this point of view the study of East African *Bostrychia* would probably prove interesting.

Mangroves

There are extensive mangrove swamps along the creeks and around islands. In the south at Vanga, Shirazi and Gazi; in the central region in the Mombasa area, especially Tudor Creek and its branches, at Mtwapa, Kilifi and Mida Creek; but the most extensive growths of mangrove occur in the north on the mainland and around the islands of the Lamu archipelago. (Fig. 1).

A detailed study of the mangrove swamps has not been attempted by the authors. This brief account which has drawn to a great extent on Graham's paper (1928), will give the character of the chief species.

RHIZOPHORA MUCRONATA Lam. *Mkoko* (Swa.) (Plate 1,A). This is the commonest and most important economically. It can be recognised by its stilt roots which are sent down both from the main stem and from the branches; those from the higher branches may not grow as far as the mud. The leaves are broadly elliptical and strongly mucronate. The embryos which grow and develop hanging from the tree are from 40–60 cm. in length. When they fall into the water they float vertically until they settle on a suitable substratum and begin to grow.

BRUGUIERA GYMNORRHIZA (L.) Lam. *Muia, Mrifu* (Swa.) (Plate 1, B). This is in some respects similar to *Rhizophora* but it has buttress roots near the base of the trunk and the leaves are not mucronate. The embryos, of the same plummet type, are shorter and smaller. *Bruguiera* sends up characteristic "knee-like" pneumatophores from its roots for purposes of aeration.

CERIOPS TAGAL (Perr.) C. B. Robinson *Mkanda* (Swa.) (Plate 1, C). A small tree or shrub which is buttressed at the base, has "knee-like" pneumatophores, smaller obovate leaves and slender, ribbed embryos.

AVICENNIA MARINA (Forsk.) Vierh. *Mchu, Mtu, Mutu* (Swa.) (Plate 1, D). This is often a spreading much branched tree in favourable conditions but may be stunted and shrubby in other places. It has ovate or broadly lanceolate leaves, often greyish on the under surface. The seeds, which germinate on the tree, are of quite a different character from those of the foregoing species. The green cotyledons folded round each other are in the shape of a compressed sphere, and slip out of a slit in the seed coat which remains attached to the tree. The plumule and radicle develop and the young plant is established as soon as it settles in a suitable place. The pneumatophores of *Avicennia* are erect and resemble stout blunt pencils.

SONNERATIA ALBA Sm. *Mililane, Mpia* (Swa.) (Plate 1, F). This is a small, spreading tree with white flowers which have many stamens giving a pompom effect. The fruits with their adhering calyces resemble spinning tops, hence the Swahili name *Mpia*. Each fruit contains many small seeds. The pneumatophores are conical.

LUMNITZERA RACEMOSA Willd. *Kikandaa, Mnwanyana* (Swa.) (Plate 1, E), is a large shrub or small tree with obovate, somewhat fleshy leaves, small white flowers which grow in a spike and have prominent green calyces. It has "knee-like" phenumatophores.

XYLOCARPUS GRANATUM Koen. (Syn. *Carapa obovata* Bl.), is a small tree, much less frequent than those mentioned above. It can be easily recognised by its compound leaves and its large, hard football-like reddish-brown fruits often 6 ins. or more in diameter. This tree has ribbon roots which protrude from the mud to fulfil the same aeration purposes as pneumatophores.

HERITIERA LITTORALIS Ait. usually grows along the water margins of a swamp. *Ceriops* and *Avicennia* may grow with it or slightly further in. In deeper mud *Rhizophora* and *Bruguiera* flourish and on the landward side *Lumnitzera* and to a lesser extent *Avicennia* may cover extensive areas which are only infrequently inundated by the sea.

On sandy areas in and around mangrove a creeping succulent, *Sesuvium portulacastrum* (L.) L., is frequently found.

Marine Angiosperms

Three families of marine angiosperms are well represented on the Kenya coast.

POTAMOGETONACEAE.	*Cymodocea*	*ciliata* Ehrenb. ex Aschers.
	,,	*serrulata* (R. Br.) Aschers.
	,,	*rotundata* Aschers. et Schweinf.
	Halodule	*uninervis* (Forsk.) Aschers.
	,,	*wrightii* Aschers.
	Syringodium	*isoetifolium* (Aschers.) Dandy.
HYDROCHARITACEAE.	*Halophila*	*ovalis* (R. Br.) Hook. f.
	,,	*minor* (Zoll.) Hartog.
	,,	*balfourii* Solered.
	Thalassia	*hemprichii* (Ehrenb.) Aschers.
	Enhalus	*acoroides* (L.f) Rich. ex Steud.
ZOSTERACEAE.	*Zostera*	*capensis* Setchell.

None of the species is endemic and some of them have a most interesting distribution pattern in the Indian, Pacific and Atlantic oceans and, with the exception of *Zostera*, they are nearly all confined to the tropics.

When considering the Kenya coast in general, by far the most prominent species are *Cymodocea ciliata* (Plate 2. F) and *Thalassia hemprichii* (Plate 2, H). They are both plentiful and are found in most places where the substratum is suitable, that is, where there is rock or old coral covered to a greater or lesser degree by sand. They root firmly on the substratum and can withstand fairly rough wave action. *C. ciliata* has not been found in sheltered creeks away from the open sea but *T. hemprichii* does sometimes occur in such places where it becomes luxuriant and may root at a considerable depth.

C. ciliata is at its maximum development both in density of plants and size of individuals in deeper water either within the reef or beyond it, where it is never emersed. It is common in a more stunted form in pools and channels high on the shore where at low water springs it is often at or near the surface of the water with the leaves showing but always wet.

T. hemprichii is abundant at varying depths between the shore and the reef and on flat areas on the landward side of the reef. In and around pools close inshore it is more luxuriant than on flat areas where it is uncovered at low water springs and often shows a marked degree of burning after exceptionally low tides. It frequently forms a dense and dominant mat which gives shelter to many small animals and algae such as *Halimeda opuntia* (Plate 5,B).

Halodule uninervis (Plate 2,C) and *H. wrightii* (Plate 2,B) are both common and widespread but since they are smaller plants covering less extensive areas they are less conspicuous. Highest on the shore is *H. wrightii* frequently in association with *Halophila ovalis* and *H. minor* (Plate 2,L and K). *Halodule wrightii* has narrow grasslike leaves and is able to withstand considerable periods of emersion. It extends in a more luxuriant form into pools in the upper intertidal area but has not been found in deeper water. *H. uninervis* has somewhat broader leaves and is more frequently found in pools and shallow sheltered water where, if uncovered by the tide, it is usually wet. In deeper water in creeks this plant may have branching, almost woody, upright stems and tougher somewhat narrower leaves.

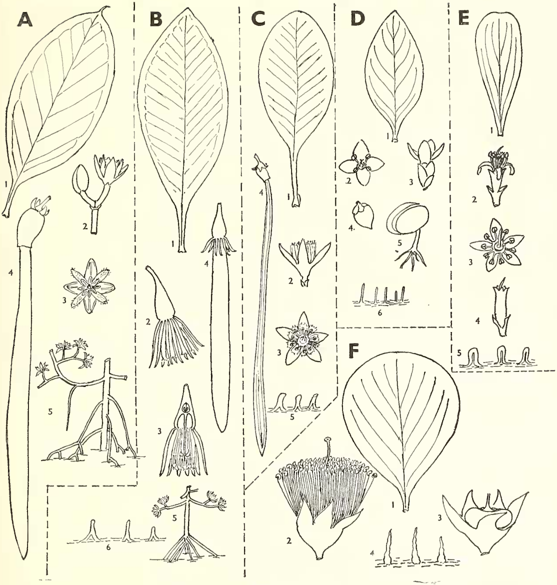

Plate 1

A. *Rhizophora mucronata* Lam. 1. leaf × $\frac{1}{4}$; 2. flower and bud × 1; 3. flower × 1; 4. embryo × $\frac{1}{4}$; stilt roots (diagrammatic).

B. *Bruguiera gymnorrhiza.* (L.) Lam. 1. leaf × $\frac{1}{4}$; 2. flower × $\frac{1}{2}$; 3. longitudina section of flower × $\frac{1}{2}$; 4. embryo × $\frac{1}{4}$; 5. buttress roots (diagrammatic); 6. pneumatophores (diagrammatic).

C. *Ceriops tagal* (Perr.) C. B. Robinson. 1. leaf × $\frac{1}{4}$; 2, 3. flower × 1; 4. embryo × $\frac{1}{4}$; 5. pneumatophores (diagrammatic).

D. *Avicennia marina.* (Forsk.) Vierh. 1. leaf × $\frac{1}{2}$; 2, 3. flower × 2; 4. young fruit × $\frac{1}{2}$; 5. embryo × $\frac{1}{2}$; 6. pneumatophores (diagrammatic).

E. *Lumnitzera racemosa.* Willd. 1. leaf × $\frac{1}{2}$; 2, 3. flower × 2; 4. young fruit × 1; pneumatophores (diagrammatic).

F. *Sonneratia alba.* Sm. 1. leaf × $\frac{1}{2}$; 2. flower × $\frac{1}{2}$; 3. young fruit × $\frac{1}{2}$; 4. pneumatophores (diagrammatic).

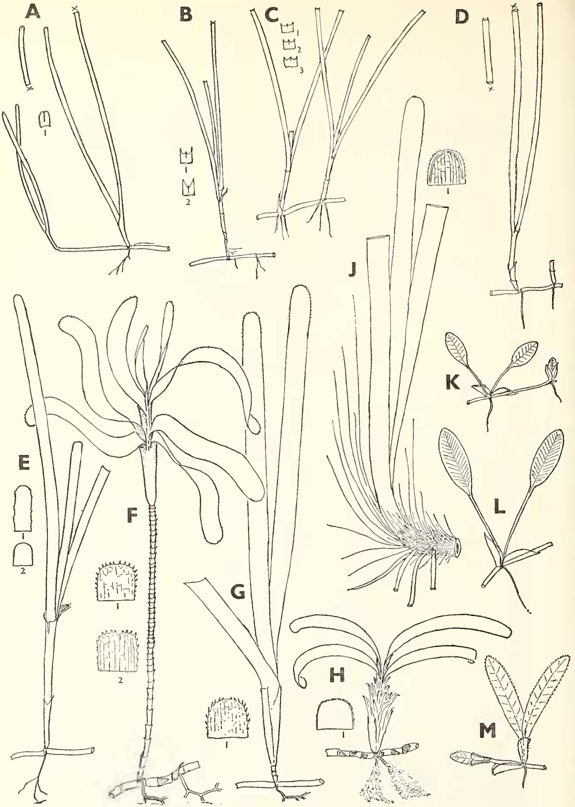

Plate 2

A. *Zostera capensis* × 1; 1. leaf tip × 2;
B. *Halodule wrightii* × 1; 1, 2. leaf tip variations × 4;
C. *H. uninervis* × ½; 1, 2, 3. leaf tip variations × 2;
D. *Syringodium isoetifolium* × ½;
E. *Cymodocea rotundata* ½, young leaf tip slightly toothed × 1; 2. mature leaf tip with entire margin × 1;
F. *C. ciliata* × ½; 1. young leaf tip × 1; 2. mature leaf tip × 1;
G. *C. serrulata* × ½; 1, leaf tip × 1;
H. *Thalassia hemprichii* × ½; 1. young leaf tip × 1;
J. *Enhalus acoroides* × ½; young leaf tip × 1;
K. *Halophila minor* × 1;
L. *H. ovalis* × ½;
M. *H. balfourii* × ½.
del. F.M. 1.

In most places along the coast *Cymodocea serrulata* (Plate 2,G), *C. rotundata* (Plate 2,E) and *Syringodium isoetifolium* (Plate 2,D) are present, growing in and around pools and sometimes in beds in sheltered bays.

A third species of *Halophila*, namely *H. balfourii* (Plate 2,M), is found in pools and deeper water where it is never uncovered. This is much less abundant than any of the afore-mentioned species.

The rarest of the marine angiosperms on these coasts is *Enhalus acoroides* (Plate 2,J) so far only recorded from the Lamu region and Mida Creek where it grows in deep water away from the open sea. However, a bed of stunted plants was seen exposed on an old coral platform on Pate Island. *E. acoroides* has long tough strap-shaped leaves and a stout rhizome covered by the stiff bristle-like bases of old leaf margins. The rhizome is eaten by the people at Lamu and is know as *Mtimbi*.

Zostera capensis (Plate 2,A) has been found only in a few isolated localities and, since the genus usually occurs only in cold or cool temperate regions, it is surprising that it should grow at all on these shores.

Both leaves and stems of many of the marine angiosperms are frequently coated with a wide variety of both epiphytic algae and small marine animals.

Algae of sandy and muddy areas

The sandy and muddy areas do not have an extensive algal flora although locally, certain species may be common. Thus in the soft mud at Mokowe, *Avrainvillea* spp. and especially *A. amadelpha f. submersa* is common. In this area in July 1965 there were dense growths of *Caulerpa* spp. Large plants of *C. scalpelliformis* were common and numbers of plants were growing together; *C. sertularioides* was almost as common and plants of *C. racemosa* (Plate 5, G) and *C. verticillata* were also found. In March 1967 fewer Caulerpas were seen in this area. Growing out of the soft substratum were large plants of *Halimeda macroloba* (Plate 5, A) which was much more plentiful in March 1967 than in July 1965. Very common on stones, sticks etc. were clumps of large *Neomeris van-bosseae*. In this area also a fair number of plants of *Udotea orientalis* and *Gracilaria cacalia* were present as well as scattered individuals or clumps of a number of other species.

In some sandy areas shoreward of the reef at the southern end of Diani Beach large numbers of scattered plants of *Halimeda macroloba* occur. In sandy areas of the Silversands reef (Malindi) also, scattered plants of this species are a feature some distance away from the reef edge.

Regarding algae found both on the reef and in the area to seaward of mangrove, one feature deserves special mention. Plants of the same species growing in mangrove mud may be fewer in number but individuals are larger and more luxuriant. This is often the case with *Padina commersonii*, *Gracilaria cacalia* and *Caulerpa scalpelliformis* as found at Gazi towards the southern end of the Kenya coast.

Algae of Rocky Platforms

PHAEOPHYTA (*Brown Algae*)

On some rocky platforms these are prominent, more especially species of Fucales and Dictyotales.

FUCALES. In places (e.g. parts of the shore of Manda Toto Island, parts of Diani Beach) emersed dwarf *Cystoseira myrica* forms a sparse cover together with the superficially similar brownish coloured *Laurencia papillosa* (Red Alga). Luxuriant forms of *Cystoseira myrica* bearing numerous small bladders occur in deep pools and at, and beyond, low water of spring tides. There may be elsewhere local concentrations, partly in and partly out of water, of *Hormophysa triquetra*. The genus *Turbinaria* is both ubiquitous and common and plants are often prominent, occurring at varying distances from low water level and may be uncovered, partly covered or completely immersed in pools at low water.

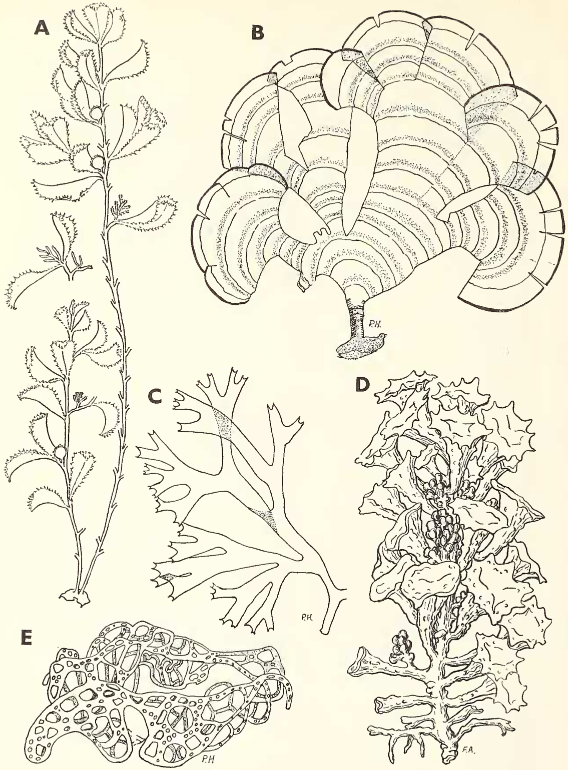

Plate 3

A. *Sargassum duplicatum* $\times \frac{1}{2}$;
B. *Padina commersoni* $\times 1$;
C. *Dictyota bartayresiana* $\times 2$;
D. *Turbinaria ornata* $\times 1\frac{1}{2}$;
E. *Hydroclathrus clathratus* $\times 1$.
A. del. F.M.I., D. F. Anderson, B.C.E. P. Hall.

One of the most widespread species is the variable *T. ornata* (Plate 3, D). In general they are lower on the shore than the *Cystoseira-Laurencia papillosa* communities referred to above. In other localities *Sargassum* ssp. of which *S. duplicatum* is illustrated, (Plate 3, A), are also very prominent, chiefly in pools or very shallow water, in which habitats they may be locally dominant. In large pools *Cystophyllum trinode* (*Cystoseira trinodis*) is sometimes a feature.

DICTYOTALES. *Padina gymnospora* and *P. commersonii* (Plate 3, B) are widespread over the reef, forming in places small, dense, local concentrations. In large shallow pools well away from the reef edge dense, extensive, almost pure communities of *P. commersonii* may be found as on the shore of Manda Island. Similar communities in similar habitats have been observed by us on Inhaca Island in Mozambique.

There are at least 5 species of *Dictyota* and these plants are sometimes common—they are certainly widespread. Although *Dictyota* plants may be found uncovered on the reef surface, they are mostly found in pools and frequently as epiphytes. One of the commonest species is the variable *D. bartayresiana* (Plate 3, C). *Dictyopteris delicatula* is a common and widespread species, a small plant and often not evident but on sorting collections it is found again and again as a constituent of clumps of small algae. *Stypopodium zonale* is widely spread at the lowest intertidal levels and in shallow water beyond low tide level of spring tides but it is not a common plant in such situations. Cast up plants are numerous, indicating that it is probably more abundant in deeper waters. Occasional plants of *Stoechospermum marginatum* (mostly small) have been found at various points along the coast. This species was found in abundance (fruiting) in August 1965 on the reef near Watamu village. At the southern end of this bay it was plentiful in a long 6 in.–1 ft. deep depressed channel through which sea-water was flowing rapidly at low water spring tide. The plants were in scattered clumps or growing singly. It was also found in still rock pools and to a limited extent completely emersed on the open platform. Large and small, repent and upright, dark and light coloured plants of *Pocockiella variegata* are widespread. They are often not readily seen since they may grow on low vertical faces or overhangs and in pools, sometimes as epiphytes.

Two species of PUNCTARIALES deserve mention here—*Colpomenia sinuosa* and *Hydroclathrus clathratus*, (Plate 3, E) more especially the latter which is not only widespread but is a common species on rocky platforms, e.g. at Diani Beach and Majuguni, Pate Island. Sometimes as on the Jadini bank at Diani at a little above low water level of neaps and well away from the open sea, it is at times a co-dominant with *Boodlea composita*, stunted *Cystoseira myrica* and *Laurencia papillosa*. The size of *Hydroclanthrus* varies from 9—over 15 cm. on the longer axis. *Colpomenia*, although widespread, is common only very locally and indidivudal plants may be of large size.

RHODOPHYTA (Red Algae)

In contrast to the coasts of South Africa (Isaac, 1953) Red Algae are not usually dominant in the intertidal areas of the Kenya coast but they are everywhere present in a less obtrusive form. In places at certain times *Liagora* spp. are common on uncovered rock surfaces of the lower shore as well as in pools as epiphytes. On ledges and flat surfaces exposed at low water and on shaded verticals high up the shore the beadlike clusters of *Acrocystis nana* (Plate 4, D) are locally common. *Gracilaria cacalia* and *G. crassa* (Plate 4, E) are common in places and the latter especially may be found uncovered at low water. *G. edulis* is common in higher level pools. *Acanthophora* is frequently a feature in water skins and pools of the upper levels, and in such localities *Hypnea valentiae* may also be found. Near low water levels *Carpopeltis maillardi* may be common. In the deeper low level pools *Actinotrichia fragilis*, *Galaxaura subverticillata* and *G. squalida* (Plate 4, F) may be fairly common. *Jania capillacea* frequently forms a dense cover on the axes of some of the larger brown algae and on *Cymodocea ciliata*. On Silversands reef clumps of *Amphiroa foliacea* several inches in diameter are locally a feature. Scattered in lower level pools and in shallow water beyond low tide level are plants of *Chondrococcus-hornemanni* and the similar but smaller *C. harveyi* (Plate 4, A) as well as *Halymenia venusta*. These, although widespread and moderately common, are conspicuous by virtue of their bright attractive colour and fleshy character and particularly in the case of *Halymenia*, the large size. Clumps of *Amau-*

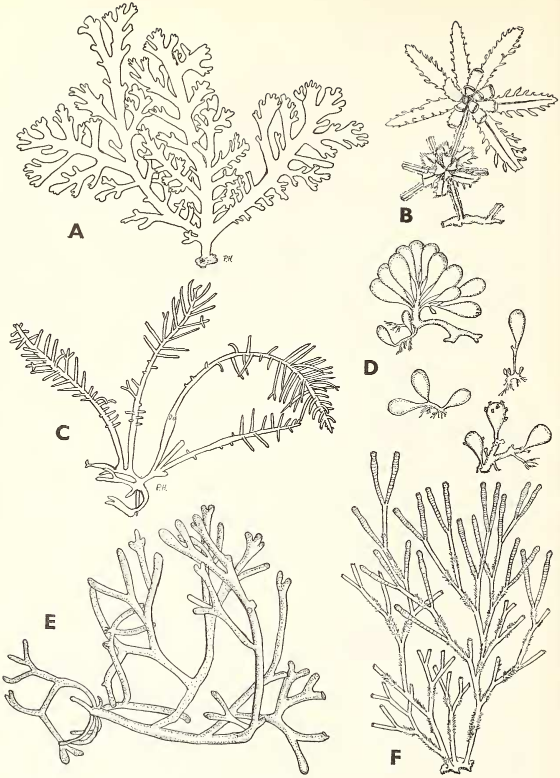

Plate 4

A. *Chondrococcus harveyi* × 2;
B. *Amansia glomerata* × 1;
C. *Gelidiella acerosa* × 1;
D. *Acrocystis nana* × 1;
E. *Gracilaria crassa* × 1;
F. *Galaxaura squalida* × 1.

A.C.E. del. P. Hall.
B.D.F. del. F.M.I.

sia glomerata (Plate 4, B) are common in pools and at low levels often in turbulent water and frequently almost obscured by the heavy coat of epiphytic growth. At the same level *Neurymenia fraxinifolia* is found and like the foregoing species it is often host to plant and animal growths and presents a dirty appearance. The widespread *Gelidiella acerosa* (Plate 4, C) must also be mentioned. Filamentous forms of red algae are prominent in places. *Ceramium* is a frequent epiphyte; *Centroceras clavulatum* is widespread and has been observed as a common species on the south Diani beach in the proximity of inflowing water from the land; in the same place fairly extensive areas of *Polysiphonia ferulacea* have been observed on sand overlying rock. This species is also abundant on sandy areas on the landward side in parts of the outer reef at Diani.

The small beautiful, intricate lace-like *Vanvoorstia spectabilis* is common in places near the reef edge where it may form small compact clumps as on the shores at Majunguni, Pate Island. At Diani it is often a pale dirty pink or brown colour. The real beauty of this plant only becomes apparent when it is viewed under a dissecting microscope.

Digenea simplex is widely distributed in warm seas. It is not common on the south Kenya coast and when present is often so covered with epiphytes that it is not easily recognised. In the Lamu region the plant is more common and cleaner, and in places occurs in almost pure narrow stands well back from the sea. The plants observed were smaller than those found on Inhaca Island (Isaac 1956). In neither of these places is it as luxuriant or abundant as at Hurghada on the Red Sea.

Many more red algae might be named but enough have been listed to indicate that, with the exception of *Liagora*, *Gracilaria* spp. and *Laurencia papillosa*, although not usually a dominant ecological feature they represent a rich constituent of the intertidal flora.

An exception to the statement that red algae do not clearly dominate a given intertidal level on the Kenya coast is the case of *Bostrychia binderi*. On verticals and overhangs at the highest level of algal growth on cliffs along the beach this small moss-like alga is dominant and growing in close association in the mat which it forms are plants of the delicate small *Catanella opuntia*.

CYANOPHYTA (Blue-green Algae)

One species of blue green alga would seem to be ubiquitous on these shores—*Lyngbya majuscula*. It is very variable in size and is found on the rock surface at varying levels and occurs also as an epiphyte. The most striking occurrence of this species was an epiphyte on stumps and leaves of *Cymodocea ciliata*, of which there are extensive beds off shore at Majunguni (Pate Island). *Lyngbya* in dense clumps streamed out into the water like tresses of grey-black hair 15 cm. or more in length. Also widespread is the tufted *Symploca hydnoides*.

CHLOROPHYTA (Green Algae)

As is to be expected on a tropical shore there is a great wealth of green algae, especially species of the groups Siphonocladales and Siphonales.

Of the Ulvales there are a number of species of *Ulva* and of *Enteromorpha*. In places species of these genera form dense or extensive growths, especially *Ulva*. Thus *Ulva*, chiefly *U. lactuca*, dominates flat platforms just above low water neaps at North Cove, Diani Beach. It may also be mentioned that on a sand-mud admixture near mangrove at the north-west end of Lamu town, a dense and extensive community of *Ulva fasciata* was observed in July 1965. At levels nearer the sea on the south and central Kenya coast extensive growths of reticulate *Ulva*, including *U. reticulata*, occur commonly tangled with other algae and most often in rock pools. The smaller *U. rigida* (Plate 5, F) is ubiquitous along the coast at different shore levels, on uncovered or water skin covered platforms and in rock pools and not infrequently as an epiphyte. It does not, however, characteristically form extensive concentrations of individuals. By and large, *Enteromorpha* is less common than *Ulva* and dense extensive growths are uncommon and usually associated with an inflow of water from the land. At the North Cove end of Diani there are extensive growths of small *E. compressa* above the *Ulva* communities and below the areas dominated by *Bostrychia binderi*.

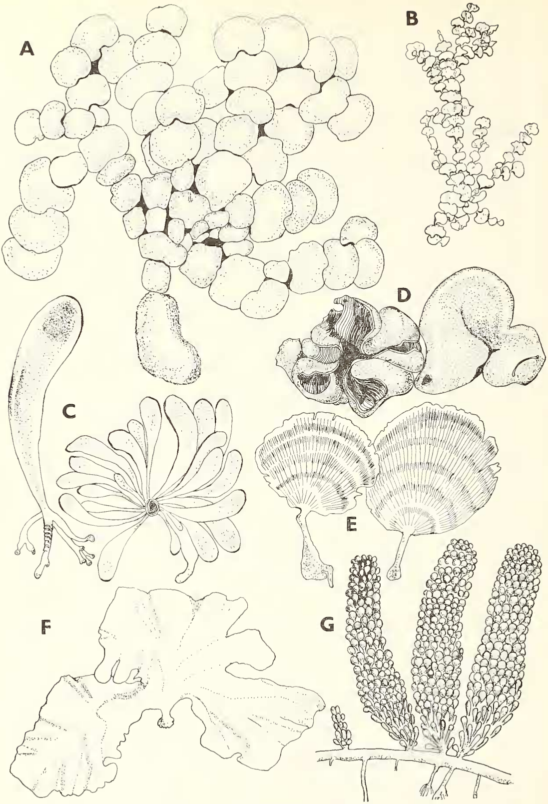

Plate 5

A. *Halimeda macroloba* × $\frac{1}{2}$;
B. *Halimeda opuntia* × $\frac{1}{2}$;
C. *Boergesenia forbesii* 1. single plant × 1; 2. cluster of plants, × 1;
D. *Dictyosphaeria cavernosa* × 1;
E. *Udotea indica* × 1;
F. *Ulva rigida* × 1;
G. *Caulerpa racemosa* × 1.

del. Mrs. P. Hall.

SIPHONOCLADALES—Widely scattered over the reef and most abundant nearer the open sea are low growing clumps of *Dictyosphaeria*, especially *D. cavernosa* (Plate 5, D) and *D. intermedia*. In water skins, depressions and pools further from the sea *Boergesenia forbesii* (Plate 5, C) may be a prominent feature as on parts of the coast of Manda Toto Island and near North Cove on Diani Beach. It is, however, a widespread feature of the reefs.

The following species tend to form clumps. At higher levels *Boodlea composita* may be common, extending upwards to above low water level of neaps. *Valoniopsis pachynema*, with or without an admixture of other species, occurs more commonly nearer the open sea. *Cladophoropsis membranacea* also occurs at different levels. In the Lamu area some more or less extensive clumps of *Ernodesmis verticillata* were observed at lower and intermediate levels.

Anadyomene is widespread and is sometimes fairly common. It occurs on uncovered reef in small sheltered depressions and in pools. *Struvea* is widespread as are also species of *Valonia*.

SIPHONALES—The most common are *Udotea*, *Halimeda* and *Caulerpa*. *Udotea indica* (Plate 5, E) is widely distributed on the reef varying considerably in size and character. It is sometimes very abundant. The larger lighter coloured *U. orientalis* is primarily a plant of quiet waters as in areas to seaward of mangrove. At least six species of *Halimeda* occur here. Of these *H. opuntia* (Pate 5, B) may form large sized masses in sand on the reef and elsewhere. These clumps may be almost completely buried in the sand. This is a feature shown by several species of *Halimeda*. The most outstanding exception is perhaps *H. macroloba* (Plate 5, A), the upper parts of which stand up clearly above the substratum. *H. tuna* is widespread at lower levels and in pools.

In the published lists of Kenya marine algae (Isaac, 1967, 1968) there are over 20 species and varieties of *Caulerpa* listed. Some of these such as *C. sertularioides*, *C. scalpelliformis*, *C. verticillata* and the very variable *C. racemosa* (Plate 5, G) are common and widespread. Others are less common and more characteristic of particular habitats. They will be dealt with more fully in a forthcoming paper. *Codium* is widespread but only very locally common, as for example *C. capitatum* in large pools at Shimo-la-Tewa. Brilliant green clumps and larger patches of *Chlorodesmis* may sometimes be extensive. *Avrainvillea* is a genus of sand and mud areas rather than of reefs.

Of the Dasycladales, *Neomeris van bosseae* is widespread and sometimes common.

CLADOPHORALES—There are several species of *Cladophora* and the genus is widely distributed on the Kenya coasts. *Chaetomorpha crassa* deserves mention as it often forms quite considerable 'balls of green string' usually entangled with other algae.

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